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BEEF CARCASS MATURITY INDICATORS AND PALATABILITY ATTRIBUTES¹

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Summary

The relationship of certain beef carcass maturity indicators to the palatability of cooked beef was evaluated by use of *longissimus* muscle samples from 195 wholesale ribs. Carcasses in U.S.D.A. maturity groups A and B were selected on the basis of differences in the vertebral column, ribs and exposed lean; while those in U.S.D.A. maturity groups C, D and E were assigned to selection classes according to the degree of ossification in the cartilaginous tips of the fifth, eighth and 10th thoracic vertebrae. All of the skeletal and muscle maturity scores were significantly correlated with palatability attributes. Correlations between individual maturity scores and palatability traits were of the same approximate magnitude suggesting little difference among indices of physiological maturity in explaining the observed variability in eating satisfaction. Few significant differences were detected among selection classes or U.S.D.A. maturity groups for scores assigned to tongue and cheek pressure, tooth pressure, mealiness, adhesion, fragmentation and juiciness or for shear force values. It is evident that the tenderizing or toughening effect of cookery may vary depending upon the cookery method and the final internal temperature of the cooked samples derived from various maturity groups. For complete appraisal of such effects, experiments in which more rare and well-done samples are evaluated should be considered. Therefore, results of the present study must be interpreted consistent with the cookery methods em-

ployed. Tenderness ratings assigned to samples from E and E+ maturity carcasses were usually inferior to those assigned to samples from carcasses in the other maturity groups. Although samples from the most youthful carcasses were more tender than those from the most mature carcasses, differences in tenderness between samples in eight selection classes in the A and B maturity groups were of small magnitude and not linearly related to advancing maturity. Results of the present study suggest that the number of maturity groups used in assigning U.S.D.A. quality grades to beef carcasses could be reduced.

Introduction

Appraisals of carcass maturity are included in the U.S.D.A. (1965) beef grading standards on the assumption that advancements in physiological maturity result in decreased tenderness. Previous studies have indicated that substantial differences in tenderness exist between muscle samples from very youthful as compared to very mature carcasses (Romans, Tuma and Tucker, 1965; Walter *et al.*, 1965; Breidenstein *et al.*, 1968). However, comparisons among youthful carcasses have demonstrated few significant differences in tenderness which could be attributed to relative physiological maturity (McBee and Wiles, 1967; Breidenstein *et al.*, 1968; Covington *et al.*, 1970; Norris *et al.*, 1971). Research studies have failed to identify a specific point in time (chronological age or physiological maturity) at which a definite decrease in tenderness occurs. Correspondingly, the assumption has been that the effects of maturity on palatability attributes (especially tenderness) are progressive, accumulative and linear.

The procedure employed in the U.S.D.A. beef grading standards of requiring higher degrees of marbling to compensate for the assumed adverse effects of maturity on palatability has been questioned, especially for more

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youthful carcasses (A- to A+ maturity). The relative importance of skeletal vs muscle maturity indicators in determining physiological age has also been of considerable concern. Correspondingly, it is of current interest to identify the carcass maturity indicators which are related to tenderness and to identify the stage in the physiological development of the bovine at which maturity exerts its greatest influence on tenderness.

The purpose of the present study was to determine the relationship of singular and combined measures of physiological maturity to the tenderness and juiciness of cooked beef muscle.

Materials and Methods

A total of 195 wholesale beef ribs were selected from intact carcasses of unknown history to represent the physiological maturity descriptions for the 22 selection classes described in table 1. Each carcass was evaluated, usually with the assistance of representatives of the Meat Grading Branch of the Agricultural Marketing Service, U.S.D.A., for the following factors: the degree of ossification in the cartilaginous tips of the first through the sixth thoracic vertebrae, the seventh through the 13th thoracic vertebrae, the lumbar vertebrae and the sacral vertebrae; rib structure and color; muscle color and texture; marbling score and U.S.D.A. quality grade. Scores for skeletal and lean maturity characteristics were assigned on the basis of U.S.D.A. (1965) descriptions and assigned scores on a 15-point scale (A- = 15; E+ = 1). Carcasses and subsequent wholesale ribs which exhibited U.S.D.A. marbling scores in the slight, small and modest classifications were selected. To facilitate comparisons of U.S.D.A. maturity groups, each of the 195 carcasses was assigned an overall maturity classification by use of the descriptions and system provided in U.S.D.A. (1965) beef grading standards.

After an 8- to 10-day postmortem aging period, 100 g samples (approximately 6.5 cm long and 2.3 cm thick) of the *longissimus* muscle were obtained from the 12th thoracic vertebra region of each wholesale rib. The steaks were individually double-wrapped in polyethylene-coated paper, frozen and stored at -23°C until subsequent taste panel evaluations.

The steaks were placed in a 3°C cooler for 12 hr. prior to cooking to facilitate insertion of metal thermocouples. Each steak was individually oven-broiled for 35 min. in a preheated

gas oven maintained at 180 centigrade. Analysis of data indicated that under these conditions of cookery, a 35 min. time period produced steaks with a mean internal temperature of 71.4 \pm 0.15°C, typical of a medium degree of doneness. The thermocouples were connected to a temperature recorder which measured the internal temperature of each steak every 60 sec. for the 35 min. duration of cooking. Meat samples were independently scored by a six-member trained sensory panel for juiciness and the various components of the tenderness profile system (softness to tongue and cheek, softness to tooth pressure, ease of fragmentation, mealiness, adhesion, amount of connective tissue, softness of connective tissue) as described by Cover, Ritchey and Hostetler (1962). Warner-Bratzler shear force measurements for each steak were performed in duplicate on two 1.27 cm cores which were removed after the samples had cooled to 25°C.

Reduction of data was achieved using analysis of variance, while mean separation analyses were performed using the Kramer (1956) modification of the Duncan (1955) Multiple Range Test.

Results and Discussion

Mean separation analyses for various traits and measures were performed among selection classes and among U.S.D.A. maturity groups. In data not presented in tabular form, samples derived from youthful and mature carcasses sustained similar cooking losses. The lack of significant differences in cooking loss between samples from the extremes of the U.S.D.A. maturity classification system are in agreement with the results of Goll *et al.* (1965) and Breidenstein *et al.* (1968). Internal temperatures obtained at 60 sec. intervals during the 35 min. cooking period were quite similar among samples from the various maturity groups. No significant difference in the internal temperature of steaks among selection classes or maturity groups was observed.

Mean values for the various components of the tenderness profile system, juiciness scores and shear force values, stratified according to selection class, are presented in table 2. With the exception of samples in selection class 22, tooth pressure scores were similar for all samples from all selection classes. Ho and Ritchey (1967) observed significantly lower scores for both tongue and cheek and tooth pressure in steaks derived from animals over 2 years of age at slaughter as compared to those from baby

180 centigrade. Analysis under these conditions of a period produced steaks temperature of $71.4 \pm$ medium degree of doneness were connected to a which measured the internal steak every 60 sec. for cooking. Meat samples rated by a six-member panel for juiciness and the the tenderness profile (tongue and cheek, softness of fragmentation, mealiness of connective tissue, tissue) as described by Stetler (1962). Warner- measurements for each n duplicate on two 1.27 mm moved after the samples

as achieved using analysis separation analyses (Kramer (1956) modified (1955) Multiple Range

Discussion

lyses for various traits formed among selection U.A. maturity groups. In tabular form, samples and mature carcasses ng losses. The lack of cooking loss between emes of the U.S.D.A. system are in agreement (1965) and (1968). Internal temperature intervals during the 35 are quite similar among s maturity groups. No the internal temperature classes or matur-

various components of system, juiciness scores stratified according to ented in table 2. With es in selection class 22, ere similar for all samples. Ho and Ritchey antly lower scores for and tooth pressure in als over 2 years of age d to those from baby

TABLE 1. CLASSIFICATION SCHEME FOR SELECTING BEEF RIBS ON THE BASIS OF SKELETAL AND MUSCLE MATURITY CHARACTERISTICS AND OSSIFICATION IN THE CARTILAGINOUS TIPS OF THE DORSAL SPINOUS PROCESSES

Selection class	n	U. S. D. A. maturity group for skeletal characteristics ^a	U. S. D. A. maturity group for muscle characteristics ^a	Amount of cartilage ossification in tip of dorsal spinous process ^b		
				Fifth thoracic vertebrae	Eighth thoracic vertebrae	Tenth thoracic vertebrae
1	10	A-	A-	None	None	None
2	11	A	A-	Less than 1/3	Less than 1/3	Less than 1/3
3	11	A	A+	None	Less than 1/3	Less than 1/3
4	10	A+	A+	Less than 1/3	Less than 1/3	Between 1/3 & 2/3
5	10	A	A	Less than 1/3	Less than 1/3	Between 1/3 & 2/3
6	8	A+	A+	Less than 1/3	Less than 1/3	Between 1/3 & 2/3
7	8	A-	A-	Less than 1/3	Less than 1/3	Between 1/3 & 2/3
8	7	B-	B-	Less than 1/3	Less than 1/3	Between 1/3 & 2/3
9	8	B-	B+	Less than 1/3	Less than 1/3	Between 1/3 & 2/3
10	11			None	None	None
11	9			Less than 1/3	Less than 1/3	Less than 1/3
12	6			None	Less than 1/3	Less than 1/3
13	8			Less than 1/3	Less than 1/3	Between 1/3 & 2/3
14	10			Less than 1/3	Less than 1/3	Between 1/3 & 2/3
15	9			Less than 1/3	Less than 1/3	Between 1/3 & 2/3
16	6			Less than 1/3	Less than 1/3	Between 1/3 & 2/3
17	7			Less than 1/3	Less than 1/3	Between 1/3 & 2/3
18	10			Less than 1/3	Less than 1/3	Between 1/3 & 2/3
19	8			Less than 1/3	Less than 1/3	More than 2/3
20	9			Less than 1/3	Less than 1/3	More than 2/3
21	1			Less than 1/3	Less than 1/3	More than 2/3
22	11			More than 2/3	More than 2/3	More than 2/3
				Complete ossification	Complete ossification	Complete ossification

^aBased on descriptions provided in U.S.D.A. (1965) beef grading standards.

^bFractional quantities refer to the amount of the surface area of the cartilaginous tip (button) which was ossified. Cartilaginous vertebrae were numbered from the cranial end of the carcass (first thoracic vertebra articulates with the rib nearest the cervical vertebrae).

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TABLE 2. MEAN VALUES FOR SENSORY PANEL SCORES AND SHEAR FORCE VALUES STRATIFIED ACCORDING TO SELECTION CLASS

Selection class	Tongue and cheek pressure score ¹	Tooth pressure score ¹	Meatiness score ¹	Adhesion score ¹	Fragmen-tation score ¹	Connective tissue amount score ¹	Connective tissue softness score ¹	Shear force value, kg	Juiciness score ¹
1	5.62a	5.58a	5.84a	2.86abcd	6.13abc	6.17abc	8.71ab	3.97a	4.37abcd
2	5.58a	5.69a	5.81a	2.68bcd	6.02abc	6.20abcde	8.03abcd	3.98a	4.62abc
3	5.44a	5.62a	6.13a	3.07abcd	6.60a	6.62a	8.84a	3.86a	4.08cd
4	5.58a	5.62a	5.82a	2.98abcd	6.15abc	6.24abc	8.80a	4.18a	3.94d
5	5.36a	5.45a	5.82a	2.92abcd	5.44bcd	6.15abc	8.64abc	8.1abc	4.38abcd
6	5.45a	5.72a	5.74a	2.83abcd	6.10abc	6.10abc	8.52abcd	8.35abcd	4.19cd
7	5.58a	5.72a	5.88a	3.22ab	6.44ab	6.55ab	8.88a	8.81a	4.24abcd
8	5.56a	5.72a	6.27a	3.40a	6.72abc	6.88abc	7.95abcd	4.14a	4.24abcd
9	5.62a	5.63a	6.45ab	3.06abc	6.92abc	6.01abc	7.08abcd	3.99a	4.38abcd
10	5.61a	5.69a	5.63a	2.70bcd	5.94abc	6.04abc	8.61abcd	8.20abcd	4.69a
11	5.69a	5.97a	5.97a	2.84abcd	6.46ab	6.30abc	8.23abcd	7.50bcd	4.75a
12	5.75a	5.38ab	5.38ab	2.82abcd	5.28abcd	6.92abcd	8.29abce	8.18abcd	4.37abcd
13	5.49a	5.66a	5.49ab	2.91abcd	6.04abc	6.25abc	7.82cdef	7.48cde	4.05a
14	5.73a	5.52a	5.66a	2.94abcd	6.11abc	6.23abc	7.84def	7.6de	4.08a
15	5.52a	5.06a	5.06a	2.70bcd	5.36bcd	5.58bcd	7.72ef	7.66cde	4.76a
16	5.82a	5.67ab	5.82a	5.48cd	5.97abcd	5.58bcd	8.10abcd	7.64cde	4.56a
17	5.56a	5.86a	5.86a	3.10abc	6.30abc	6.00abc	7.57ef	4.56a	5.07a
18	5.66a	5.67a	5.66a	5.24ab	5.27abcd	5.36abc	7.91bcdef	7.33cde	4.04bcd
19	5.75a	5.75a	5.81a	2.91abcd	5.29acd	5.44bcd	8.03bcde	7.58cde	4.79ab
20	5.38a	5.43a	4.98a	2.56cd	5.94abc	6.24abc	8.10abcd	7.28bcde	4.56abcd
21	5.31a	6.43a	6.00a	2.67cd	6.36bcd	6.51bcd	7.61efg	7.44de	4.67abc
22	5.31a	6.31a	4.48b	2.47d	6.19cd	6.44cd	7.13fg	6.92ef	4.64abc
					2.47d	4.85d	6.92g	6.52f	4.44bcd

a, b, c, d, e, f, g Means in the same column bearing different superscripts are significantly ($P < .05$) different.
 Scores based on a 9-point rating scale.

beef. Cooked samples from the selection classes of more advanced maturity (20, 21, 22) were less mealy upon repeated chewing than were samples from the more youthful selection classes. Muscle fibers in cooked samples from selection classes 21 and 22 displayed greater adhesion to each other and were more difficult to fragment upon repeated chewing than fibers from samples in some of the more youthful selection classes (3, 7, 11). The similarity in fragmentation scores in classes 1 through 8 agrees with the findings of Ho and Ritchey (1967); however, Ritchey and Hostetler (1964) observed lower fragmentation scores in meat samples from 62-week-old cattle as compared to 33-week-old cattle when steaks were cooked to 61 centigrade.

Scores for amount and softness of connective tissue were generally lower (indicative of greater amounts of stromal protein and connective tissue that was less susceptible to mastication) among samples in selection classes which were from physiologically more mature carcasses. However, samples from selection class 2 (typical A maturity muscle and skeletal characteristics) and selection class 8 (B-maturity skeletal through A+ maturity muscle) were assigned scores for amount of connective tissue which were similar to those assigned to samples in some of the more advanced maturity classes. Moreover, samples from selection classes 15 and 19 were assigned sensory panel scores for amount of connective tissue which were similar to those assigned to samples in the most youthful selection classes. Scores for connective tissue softness closely paralleled those for amounts of connective tissue.

Shear force values did not differ among the 22 selection classes. However, there was considerable variability ($SD = 1.4$ kg for entire population) in shear force within selection classes. While sensory panel scores for adhesion, fragmentation and connective tissue amount and softness indicated that samples from more mature carcasses were less tender than those from more youthful carcasses, these differences were not reflected in shear force requirements. Correlation coefficients between shear force value and scores for tooth pressure ($r = -.72$), adhesion ($r = -.63$), fragmentation ($r = -.73$), amount of connective tissue ($r = -.13$) and softness of connective tissue ($r = -.15$) indicate that shear force requirements were more indicative of differences in muscle fiber hardening and protein coagulation, than they were of the amount or softness of connective tissue. It is possible that the method of cookery used in the present study affected tenderness measurements by the Warner-Bratzler shear producing either toughening of muscle samples from youthful carcasses or tenderization of muscle from mature carcasses. Schmidt, Kline and Parrish (1970) concluded that assessment of the effects of maturity on tenderness must take into account the effects of the interaction of maturity with the final internal temperature of cooked muscle.

Mean values for sensory panel scores and shear force values stratified according to U.S.D.A. maturity group are presented in table 3. Tooth pressure scores indicated that samples from more mature carcasses were hardened to a greater extent than those from youthful carcasses by the cooking procedure. It is obvious

TABLE 3. MEAN VALUES FOR SENSORY PANEL SCORES AND SHEAR FORCE VALUES STRATIFIED ACCORDING TO U.S.D.A. MATURITY GROUP

U.S.D.A. maturity group	Tongue and cheek pressure score ^a	Tooth pressure score ^a	Mealiness score ^a	Adhesion score ^a	Fragmentation score ^a	Connective tissue amount score ^a	Connective tissue softness score ^a	Shear force value, kg	Juiciness score ^a
A-	5.62 ^a	5.84 ^{ab}	2.86 ^{abc}	6.13 ^{abc}	6.17 ^{abc}	8.71 ^a	8.67 ^a	3.97 ^a	4.37 ^a
A	5.56 ^a	5.91 ^a	2.87 ^b	6.26 ^a	6.27 ^a	8.52 ^a	8.39 ^a	4.07 ^a	4.31 ^a
A+	5.51 ^a	5.72 ^{ab}	2.95 ^a	5.80 ^{abc}	6.20 ^{ab}	8.72 ^a	8.63 ^a	4.39 ^{ab}	4.16 ^a
B-	5.55 ^a	5.99 ^a	3.21 ^a	6.44 ^a	6.54 ^a	8.58 ^a	8.41 ^a	4.03 ^a	4.34 ^a
B	5.56 ^a	5.62 ^{ab}	2.84 ^{abc}	5.80 ^{abc}	6.04 ^{abc}	8.80 ^a	8.67 ^a	3.99 ^a	4.44 ^a
B+	5.85 ^a	5.90 ^a	2.98 ^a	6.38 ^a	6.48 ^a	8.28 ^a	7.95 ^{abc}	3.55 ^a	4.85 ^a
C-	5.58 ^a	5.46 ^{ab}	2.82 ^{abc}	6.01 ^{abc}	6.04 ^{abc}	8.23 ^{ab}	8.06 ^a	4.66 ^{abc}	4.50 ^a
C	5.77 ^a	5.62 ^{ab}	2.72 ^b	5.98 ^{abc}	6.16 ^{abc}	7.58 ^{bc}	7.22 ^{cd}	3.98 ^a	4.52 ^a
C+	5.76 ^a	5.83 ^{ab}	2.92 ^{ab}	6.23 ^a	6.34 ^a	7.87 ^b	7.59 ^{bc}	4.04 ^a	4.79 ^a
D-	5.66 ^a	5.44 ^{ab}	2.80 ^{abc}	5.59 ^{abc}	5.84 ^{abc}	7.86 ^{bc}	7.63 ^{bc}	4.48 ^{ab}	4.76 ^a
D	5.61 ^a	5.48 ^{ab}	2.90 ^{ab}	5.64 ^{abc}	5.88 ^{abc}	7.70 ^{bc}	7.33 ^c	4.03 ^a	4.45 ^a
D+	5.36 ^a	5.01 ^{bc}	2.75 ^{bc}	5.12 ^{bcd}	5.34 ^{bcd}	7.73 ^{bc}	7.48 ^{bc}	4.98 ^{abc}	4.39 ^a
E-	5.21 ^a	4.87 ^{bc}	2.73 ^{abc}	5.67 ^{abcd}	5.54 ^{bcd}	7.19 ^{cd}	6.99 ^{cd}	4.38 ^{abc}	4.16 ^a
E	5.40 ^a	4.43 ^c	2.33 ^c	4.56 ^d	4.80 ^d	6.89 ^d	6.60 ^d	5.94 ^c	4.71 ^a
E+	5.36 ^a	4.46 ^c	2.34 ^c	4.53 ^d	4.80 ^d	6.87 ^d	6.49 ^d	5.60 ^{bc}	4.54 ^a

a,b,c,d Means in the same column bearing different superscripts are significantly ($P < .05$) different.

^aScores based on a 9-point rating scale.

a, b, c, d, e, f, f Means in the same column bearing different superscripts are significantly ($P < .05$) different.

4.44abcd

6.39a

6.52b

4.55c

5.24b

4.14a

from the results for mealiness, adhesion and fragmentation that tenderness decreased substantially between samples from E+ carcasses as compared to those from typical E maturity carcasses. Since E maturity is the most advanced maturity group recognized under U.S.D.A. standards, it is quite possible that the actual range in chronological age across the three levels of E maturity is greater than that in other maturity groups.

The sensory panel detected less connective tissue in samples from A+ through typical B maturity carcasses than in samples from carcasses of typical C or older maturity groups. The panel also detected more connective tissue in typical E and E+ maturity samples than they did in samples from D+ and younger maturity groups. Kim, Ho and Ritchey (1967) found no differences in either connective tissue amount or softness ratings between baby beef and beef derived from animals older than 2 years of age.

The lack of significant differences in shear force values between samples from A vs. E maturity carcasses and between A+ maturity vs. E+ maturity groups is in disagreement with the findings of Goll *et al.* (1965), Breidenstein *et al.* (1968) and Norris *et al.* (1971). Martin, Fredeen and Weiss (1971) observed a substantial increase in shear force requirement for muscle from beef animals which were 390 vs. 480 days of age.

Simple correlation coefficients among sensory panel scores, mechanical tenderness measurements, meat cookery data and carcass characteristics (skeletal and muscle maturity indicators, and marbling scores) are presented in table 4. Higher scores for skeletal and muscle maturity indicators are indicative of greater youthfulness. The magnitude of the correlation coefficients between individual carcass maturity characteristics and specific palatability traits were similar. Physiological changes indicative of maturity apparently occur at the same rate in all of the tissues evaluated across a broad range in physiological maturity; thus individual relationships between maturity indicators and palatability attributes are quite similar. Sensory panel scores for connective tissue amount and softness were more closely related to changes in maturity characteristics than were other palatability traits. Final internal temperature, cooking time and cooking loss were not significantly associated with carcass maturity characteristics.

Relationships between marbling and various palatability traits (table 4) were usually low; however, it should be reiterated that the range in marbling among carcasses selected for this

TABLE 4. SIMPLE CORRELATION COEFFICIENTS AMONG SENSORY PANEL SCORES, MECHANICAL TENDERNESS MEASUREMENTS, MEAT COOKERY DATA AND CARCASS CHARACTERISTICS

Trait	7th to 13th		1st to 6th		Rib maturity score	Longissimus color score	Longissimus texture score	Marbling score
	Sacral vertebral maturity score	Lumbar vertebral maturity score	thoracic vertebral maturity score	thoracic vertebral maturity score				
Juiciness score	.21**	.13	.18*	.17	.16*	.16*	.16*	.00
Tongue and cheek pressure score	.03	.06	.07	.08	.08	.10	.08	.25**
Tooth pressure score	.34**	.32**	.36**	.34**	.36**	.37**	.37**	
Mealiness score	.22**	.17*	.24**	.25**	.22**	.24**	.23**	.11
Adhesion score	.32**	.33**	.34**	.35**	.32**	.31**	.32**	.21**
Fragmentation score	.34**	.32**	.35**	.36**	.33**	.36**	.36**	.25**
Connective tissue amount score	.60**	.61**	.60**	.60**	.56**	.56**	.58**	.16*
Connective tissue softness score	.59**	.61**	.58**	.57**	.54**	.56**	.56**	.20**
Shear force value	.20**	.19**	.21**	.21**	.23**	.28**	.28**	.28**
Final internal temperature	.05	.08	.05	.03	.02	.00	.02	.06
Cooking loss, %	.02	.04	.02	.01	.02	.01	.04	.06

*Scores assigned on the basis of a 16-point scale (A minus = 16; E plus = 1).

**P<.01.

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TABLE 5. SIMPLE CORRELATION COEFFICIENTS BETWEEN MARBLING SCORES, SENSORY PANEL SCORES, MECHANICAL TENDERNESS MEASUREMENTS AND COOKERY DATA STRATIFIED ACCORDING TO U.S.D.A. MATURITY GROUP

Trait	U.S.D.A. maturity group				
	A	B	C	D	E
Juiciness score	-0.09	-0.11	0.14	-0.02	0.10
Tongue and cheek pressure score	0.05	0.01	0.27	-0.00	-0.12
Tooth pressure score	0.09	0.16	0.49**	0.09	-0.04
Meatiness score	-0.40**	0.15	0.18	0.20	0.05
Adhesion score	0.08	0.15	0.32*	0.09	0.10
Fragmentation score	0.05	0.14	0.45**	0.11	0.12
Connective tissue amount score	-0.02	0.12	0.03	-0.05	0.10
Connective tissue softness score	0.09	0.16	0.05	0.04	0.17
Shear force value	-0.08	-0.26	-0.49**	-0.16	0.02
Final internal temperature during cooking	0.01	0.31	-0.09	-0.28	0.08
Cooking loss	-0.18	-0.01	-0.31*	-0.04	-0.12

**P<.01.

*P<.05.

study was quite narrow (slight to modest). Correlation coefficients computed within each of the U.S.D.A. maturity groups (A, B, C, D and E) revealed that increases in marbling were more closely associated with increases in tenderness among samples from C maturity carcasses than was the case among samples in the other maturity groups (table 5).

In conclusion, samples from youthful carcasses were superior in palatability to those from more mature carcasses. However, samples from carcasses within the A and B maturity groups were similar in palatability. Carcasses in maturity groups A and B would represent the majority of the animals slaughtered in the United States for the production of block beef. The differences in tenderness observed among samples from carcasses within this range of physiological maturity (selection classes 1 through 8) were of small magnitude and did not appear to be linearly related to advancing maturity. Correspondingly, these data do not support the principle of rewarding minor advantages in youthfulness in a beef grading system. Furthermore, the separation of B and C maturity carcasses into two distinct groups in the U.S.D.A. grading system could not be justified on the basis of differences in tenderness observed in the present study. Muscle samples from typical E and E+ maturity carcasses were inferior in tenderness and thus it would appear that these carcasses should be segregated into a separate class in a beef quality grading system. Since the carcasses in this study were selected to differ in skeletal and/or muscle maturity

indicators it is possible that these data are not truly indicative of the range in carcass maturity characteristics or tenderness attributes in the population. Moreover, the study of numerous combinations of maturity indicators necessarily limits the number of observations in a specific selection class. Nevertheless, these data suggest little advantage in accounting for tenderness differences by attempts to assign different maturity classifications to carcasses which exhibit small differences in skeletal or muscle maturity indicators.

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Meatiness score	0.37**
Adhesion score	0.25**
Fragmentation score	0.25**
Connective tissue amount score	0.23**
Connective tissue softness score	0.21**
Shear force value	0.16*
Final internal temperature	0.16*
Cooking loss, %	0.06

Meatiness score	0.36**
Adhesion score	0.24**
Fragmentation score	0.24**
Connective tissue amount score	0.34**
Connective tissue softness score	0.36**
Shear force value	0.60**
Final internal temperature	0.57**
Cooking loss, %	0.02

Meatiness score	0.34**
Adhesion score	0.22**
Fragmentation score	0.22**
Connective tissue amount score	0.32**
Connective tissue softness score	0.35**
Shear force value	0.61**
Final internal temperature	0.58**
Cooking loss, %	0.02

Meatiness score	0.32**
Adhesion score	0.17*
Fragmentation score	0.33**
Connective tissue amount score	0.32**
Connective tissue softness score	0.61**
Shear force value	0.59**
Final internal temperature	-0.20**
Cooking loss, %	-0.05

Meatiness score	0.32**
Adhesion score	0.17*
Fragmentation score	0.33**
Connective tissue amount score	0.32**
Connective tissue softness score	0.60**
Shear force value	0.57**
Final internal temperature	-0.21**
Cooking loss, %	-0.03

Meatiness score	0.32**
Adhesion score	0.17*
Fragmentation score	0.33**
Connective tissue amount score	0.32**
Connective tissue softness score	0.60**
Shear force value	0.57**
Final internal temperature	-0.21**
Cooking loss, %	-0.05

Meatiness score	0.32**
Adhesion score	0.17*
Fragmentation score	0.33**
Connective tissue amount score	0.32**
Connective tissue softness score	0.60**
Shear force value	0.59**
Final internal temperature	-0.20**
Cooking loss, %	-0.08

Meatiness score	0.32**
Adhesion score	0.17*
Fragmentation score	0.33**
Connective tissue amount score	0.32**
Connective tissue softness score	0.60**
Shear force value	0.59**
Final internal temperature	-0.20**
Cooking loss, %	-0.08

^a Scores assigned on the basis of a 16-point scale (A minus = 16; E plus = 1).

^b P<.01.

^{*} P<.05.

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